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THE WATER EQUIVALENT OF SNOW ON GROUND.

By CHARLES A. MIXER, Civil Engineer, Rumford Falls, Me.

In a letter of March 7, 1903, to Dr. H. C. Frankenfield, in charge of the River and Flood Service, Mr. Charles A. Mixer, resident engineer of the Rumford Falls Power Company, at Rumford Falls, Me., on the Androscoggin River, communicates the following interesting observations:

"My usual gaging of the snow on the ground consists in simply getting a correct and full sample of the snow on the ground and then melting it to get the water equivalent. The sample is secured by forcing a cylinder down to the ground, then shoveling down around it and inserting a sheet metal bottom and lifting it out. On my voluntary observer's report for March, 1900, there is given my first report of such measurements. On account of the unusual depth of snow on the ground at a late date and its peculiar condition, I was led to make some measurements that season: these were on March 17, depth of snow, 38 inches; water equivalent, 10.49 inches; on the 31st the snow had settled to 20 inches, and the water equivalent was 9.84 inches. This represents ordinarily about 100 inches of winter snowfall, and is practically the whole winter's precipitation, to be added, when it runs off, to the greater spring precipitation. Think of this depth of water covering the surface waiting to be released, and imagine what would happen if all of it should run at once into the little river channels! This must have an important bearing on flood warnings. By gaging the snow, one can know in advance what may be expected, modified of course by considerations as to whether the snow melts and evaporates in the sunshine only or melts with the added help of a warm rain. I have kept up the measurements since my first observation in 1900, especially at the end of winter when the snow begins to go off.

"Another thought that led me first to such observations was my need of a sufficient explanation for certain monthly records of run off amounting to from 200 per cent to 500 per cent of the monthly precipitation. Of course this applies only to northern rivers, but the higher the altitude and latitude the more it means. At my present station, this season, the snow on the ground in an open place where my gage stands, measured on the 28th of February, 1903, only 19 inches, and gave 6.29 inches of water, but above us in the woods the snow is reported to be 4 to 6 feet deep. In connection with some of the northern rivers, this water that is held back, being stored in congealed form and waiting to go down, should be taken into consideration in order to get some advanced information."

RIVER FLOODS AND MELTING SNOW.

By CHARLES A. MIXER, Civil Engineer, Rumford Falls, Me., dated April 25, 1903.

The minimum discharge of the Androscoggin River occurs in February, and during the winter season the run off is controlled almost entirely by the temperature. The annual average run off is about 55 per cent of the annual precipitation, and varies monthly between 200 and 400 per cent of the total monthly precipitation. While trying to explain to myself the large run off in the springtime of from 2 to 4 times the monthly precipitation, I was led to consider the heavy covering of snow and noted it as an accumulated precipitation held in cold storage, to be released by warm weather; sometimes its release is accelerated, and its volume is increased by warm rains. In March, 1900, the depth of snow on the ground was more than the average, and being very heavy I thought to determine its water equivalent. I obtained a sample by pressing a cylinder down to the ground, digging around the outside, inserting a bottom of sheet metal and lifting out the sample. The result was entered on my monthly report as a voluntary observer, viz, March 17, snow on the ground, 38 inches; water equivalent, 10.49 inches. By the 31st the sun had settled the snow nearly one-half, and it was much heavier; the measurement gave 20 inches of snow and the equivalent water, 9.84 inches. I have made more such gagings since then, but not regularly. I have not usually made them systematically, but only at what seemed to be the end of the winter season. I have described the method to a number of others, but have never found one who had heard of it or tried it. Of course, in some parts of the country, men have no opportunity to see a large accumulation of snow or the remainder of three

or four months of snowfall. This year I measured it on February 28, 1903, and happening that day to write Prof. U. C. Grover, at Orono, Me., on hydrographic matters, I described the process and results to him. About March 16 Professor Grover made a gaging of 22 inches of snow, giving 8 inches of water. My gaging on February 28 was 19 inches of snow, giving 6.12 inches of water. Hereafter, I will make the observations frequently and regularly, and will also make them in the woods where the snow is usually twice as deep in the springtime as it is in the open space where my snow gages are. I am persuaded that such observations of the snow depths and equivalent water will be valuable everywhere, as additional information relative to the run off that may be expected, but the height of the freshet that it may produce will depend on the rate at which the snow melts. Here, at Rumford Falls, it is very interesting to see the Androscoggin rise and fall with the temperature, and to see the high discharge maintained for days in succession by the melted snow that comes first from near by and subsequently from greater distances and higher altitudes. Some simultaneous precipitation, temperature, and run off records are plotted in the accompanying diagrams, using my weather reports in connection with the daily discharge of the river, as furnished to Mr. F. H. Newell, of the United States Geological Survey, and printed in Water Supply Paper, No. 69, and subsequent numbers.

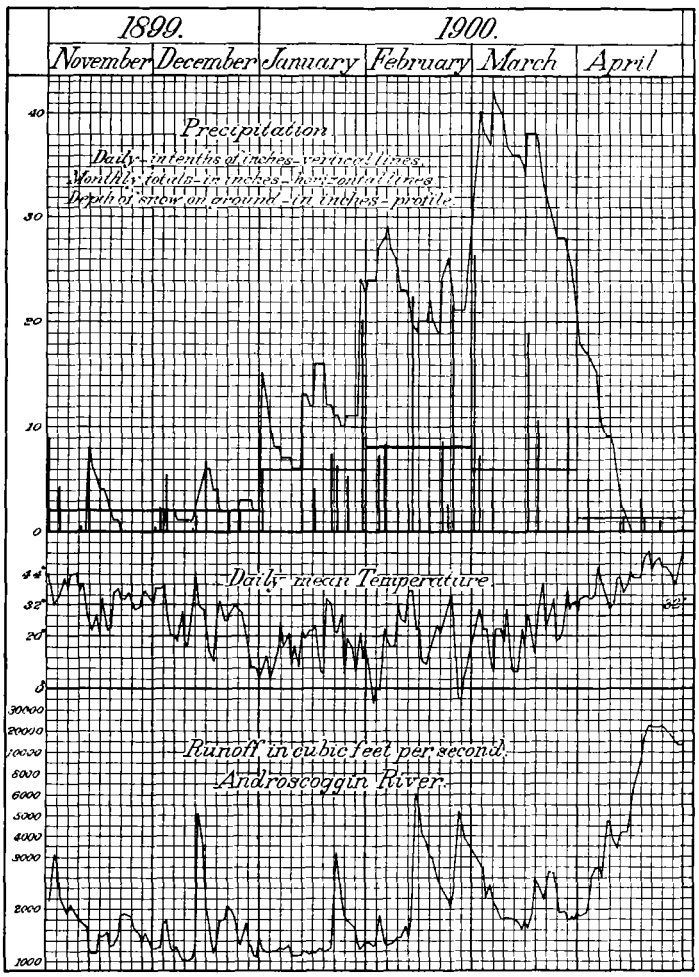

FIG. 1.—River and weather observations at Rumford Falls, Me.

These diagrams (figs. 1, 2, 3, 4) show the run off, temperature, precipitation, and the snow on the ground at Rumford Falls, Me., on the Androscoggin River, during the last four winters. It is desirable to plat more years and all of the last year, but these diagrams have been made primarily in connection with our recent correspondence concerning snow on the ground, its water equivalent, and its disappearance. The diagrams begin with the winter of 1899–1900 in order to show the heavy snowfall when I first took the water equivalent of the snow on the ground; it was a season of more than the average precipitation, mostly in snow form, and a deep accumulation of snow. The winter of 1901–2 is included as it is an example of the opposite conditions in this locality; precipitation was small, much of it as rain, and no accumulation of snow.

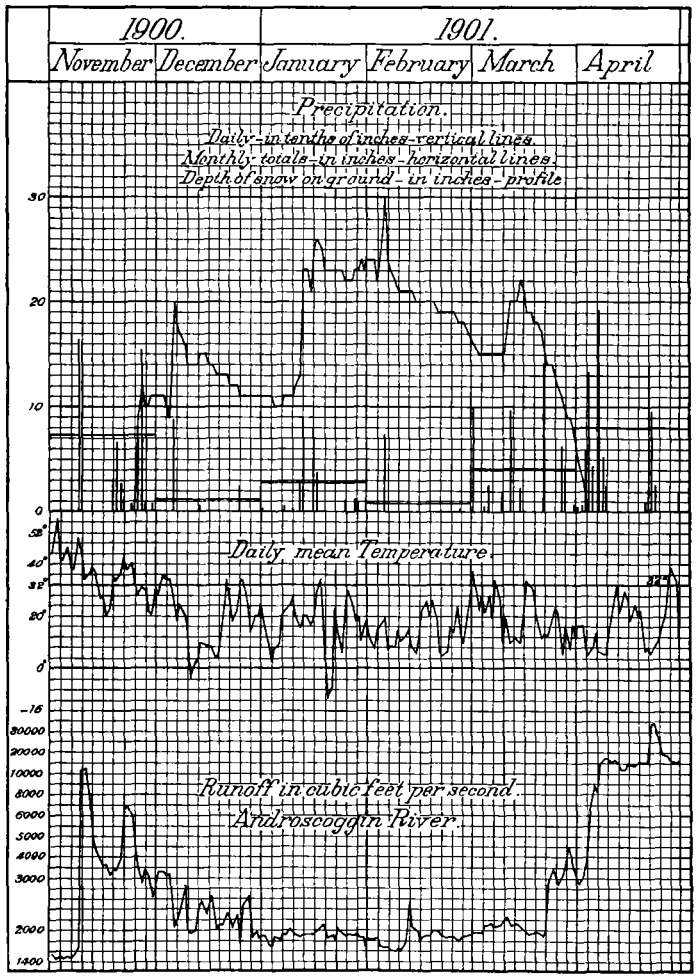

FIG. 2.—River and weather observations at Rumford Falls, Me.

It will be noticed that the vertical scale of the diagrams of run off changes, viz, the first inch is 1000 cubic feet per second; the second inch is 2000; the third inch is 7000, and the fourth inch is 50,000. Note also that this river has an extensive and well managed system of storage at an elevation of about 1000 feet higher than this station, so that the run off is regulated as much as possible. The effect of this regulation is greatest at low water and least during the freshets. Remember also that the run off measured here does not come from the precipitation received here, but from precipitation in a basin north of us with altitudes 500 to 3000 feet higher. There may not generally be much difference between the precipitation here and the average of that drainage basin. The principal effect of snow accumulation in the present studies is that the melting of the snow is delayed on the higher altitudes, and the spring freshet is prolonged beyond the complete disappearance of snow around here.

In each of the four winters it will be noticed that precipitation during a mean temperature above 32° F., therefore rain rather than snow, raises the river, but precipitation during temperatures below 32°, therefore in snow, does not affect the river. A sudden and considerable fall in temperature,

whether in connection with precipitation or not, causes an equally sudden fall of the river as on April 1, 1901; January 1, 1902; March 6, 1902; December, 1902, and February, March, and April, 1903. This is more marked if the ground be bare or has only a light covering of snow. Observe that in April, 1900, the total precipitation for the month was only 1.21 inches, but the run off of the river was maintained at more than 20,000 cubic feet per second for a week by snow melting during warm weather. Notice the close parallelism of the run off and temperature profiles during this month of April, 1900, and then compare this month with April, 1901, when the precipitation was excessive, amounting to 7.91 inches. The snow on the ground on the higher portion of the drainage basin was only ordinary, yet in combination with the warm rains the river discharge for about twenty-four hours during the parts of two days in April, 1901, reached 35,000 cubic feet per second. If the rains of 1901 had come in combination with a snow accumulation like 1900, as it sometimes does, the river discharge might have again equaled 55,000 cubic feet per second as it did in April, 1895.

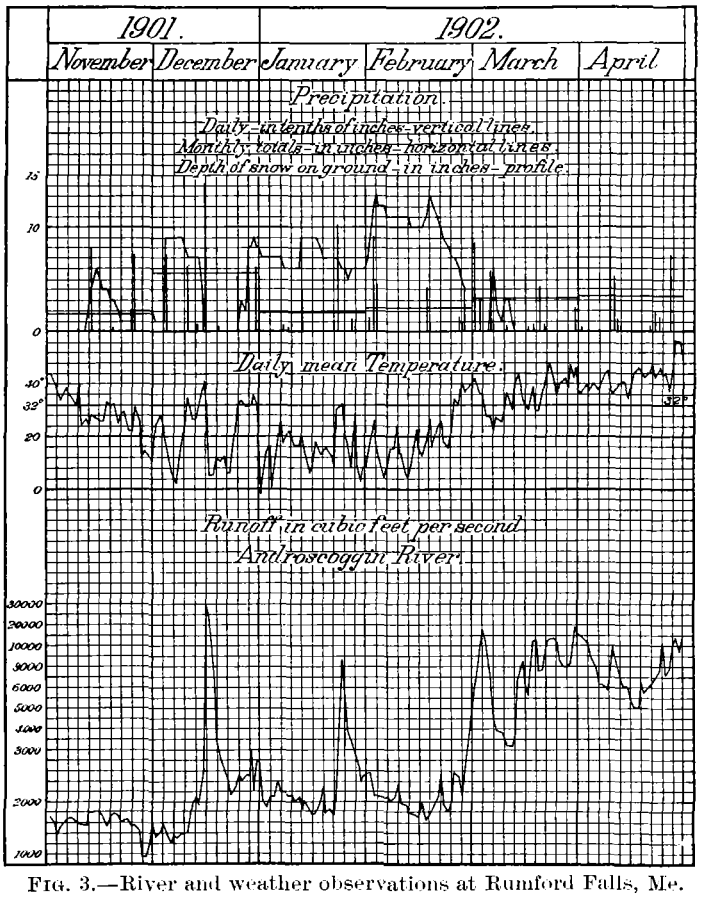

FIG. 3.—River and weather observations at Rumford Falls, Me.

All the conditions of the winter of 1901–2 were unusual. The entire season was broken and disturbed. Note the irregular monthly precipitation, coming generally with temperatures higher than 32°. The ground was bare twice; high water occurred in December, 1901, January, and March, 1902, each time carrying out the ice. The river discharge about the middle of December (made up of an ordinary amount of snow on the ground and a warm rain) was nearly 28,000 cubic feet per second, which was without precedent for the month of December. The usual spring freshet in March or April did not occur in 1902, because there was no snow on the ground and no hard rains fell. The winter just passed (1902–3) was approximately normal, excepting that it ended early, and the snow was carried off earlier than usual by the unprecedented high temperature of March last. There were no heavy rains, and an ordinary spring run off was maintained as controlled naturally by the temperature and the snow on the ground. Notice again the parallelism of the temperature and the run off profiles during March and April, 1903.

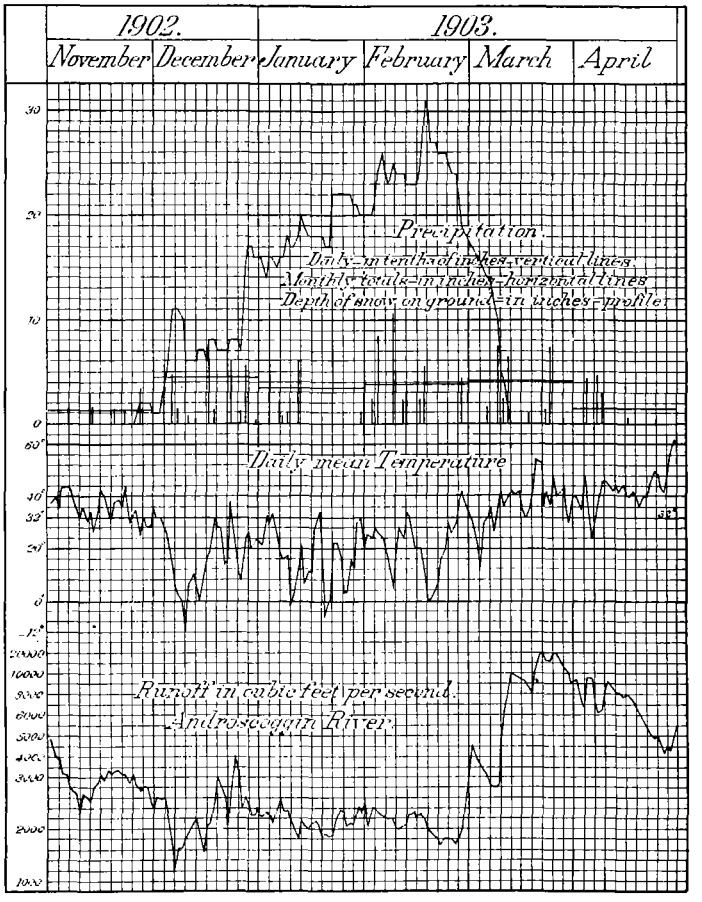

FIG. 4.—River and weather observations at Rumford Falls, Me.

Of course the limited observations and records of these four winters are not sufficient to establish any rules, but much can be learned from them. Other interesting and instructive conditions, combinations, and results may be found in these diagrams. I do not believe that another recent period as short as this could have been selected that would show so many different and extreme conditions.

TYPICAL OCTOBER WINDS ON OUR ATLANTIC COAST.

By T. H. DAVIS, dated April 13, 1903.

In Scribner's Magazine for June, 1902, there is an article by Harvey M. Watts on "The Gulf Stream myth and the anticyclone." While very much of his writing is logical and scientific he appears to me when dealing with the north Atlantic cyclone to be just as strongly imperative as was M. F. Maury with his cherished Gulf Stream. My attention has been particularly drawn to Mr. Watts' Chart No. IV, and I have made a comparison between his supposed wind directions at Boston, New York, New Haven, and Philadelphia, and the actual observations for the past eleven years at those stations. The result is that this chart does not present the winds prevailing on a typical October day.

Moreover, his explanation of so-called Indian summer, warm waves, and mild spells, does not seem to be in accordance with what are considered the fundamental principles of meteorology. Granting that the permanency of the north Atlantic cyclone is absolutely established, and that its annual north and south tropical migrations are scientific truths, how can it be shown that the anticyclonic effects can be manifested along its west-